Constraining the contribution of Gamma-Ray Bursts to the high-energy diffuse neutrino flux with 10 years of ANTARES data

Executive summary

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In this contribution, we present an analysis performed by using 10 years of data (from 2007 to 2017) collected by the large volume water-Cherenkov neutrino telescope ANTARES, located in the Northern hemisphere. In particular, we searched for up-going muon neutrinos (and anti-neutrinos) in spatial and temporal coincidence with 784 long Gamma-Ray Bursts (GRBs) occurred over these years. The numerical model NeuCosmA was used to estimate the expected neutrino flux from each burst individually, in the context of the classical internal shock model.

A novel aspect of the search here presented is the inclusion in the data analysis chain of the uncertainty that possible unknown parameters, related to the characteristics activity of the central engine of the analysed sources, can introduce in the neutrino flux evaluation. This is crucial in order to correctly interpret the validity of model-dependent results, in terms of upper limits set by non-detections of neutrinos in coincidence with GRBs. These parameters have been identified in the bulk Lorentz factor, variability timescale and source redshift, all of which are affecting the so-called dissipation radius, where shell collisions are realised.

Instead of using benchmark parameters and, thus, computing a unique neutrino flux for each GRB of the sample, we provide our results with an uncertainty band of $\pm 2\sigma$: indeed, thousands simulations for each GRB of the sample were performed by assuming values of the unknown parameters spanning their allowed ranges. As a consequence, also the stacked neutrino fluence, obtained by summing all the contributions by 784 GRBs, is presented for the first time with its error band. In light of such a study on the parameters of the model, we applied a statistical analysis on the ANTARES data in order to define the best procedure to maximise the probability to make a significant discovery.

Regarding the uncertainties in neutrino flux computation, we observed that the bulk Lorentz factor is the parameter which impacts the most GRB-neutrino flux predictions, and that the minimum variability timescale contributes more than redshift to the uncertainty on the neutrino flux predictions from GRBs.

After the unblinding of ANTARES data from the end of 2007 to 2017, no event was found to be in spatial and temporal coincidence with GRBs, and limits on the contribution of the detected GRB population to the neutrino quasi-diffuse flux were derived (and corresponding uncertainties). With these results, we provide a further and independent constraint on the contribution of GRBs to the astrophysical neutrino flux. In particular, ANTARES results indicate that GRBs are not the main sources of the astrophysical neutrino flux below $\sim$1 PeV, possibly contributing for less than 10% at energies around 100 TeV, within the framework of the classical internal shock model.